Shirley

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ON THE INCIDENCE OF CANCER IN OAK RIDGE, TENNESSEE

JACK MOSHMAN, M.A., and ALBERT H. HOLLAND, JR., M.D.

SINCE the full nature of the extent of operations at Oak Ridge was revealed after the dropping of the first atomic bomb on Hiroshima, there has been a great deal of speculation concerning the hazards of employment, or residence, in the "Atomic City." To many, radioactive chemicals suggest cancer, and one of the hitherto unanswered questions has been, "Are Oak Ridge employees, or residents, more susceptible to cancer than is the general population?"

What may be regarded as a corollary to the main question was the oft repeated query, "Will working in an area where there is possible exposure to radioactive chemicals make one more likely to develop cancer?"

PLAN OF ATTACK

In order to provide a factual, statistical answer to these questions, the Medical Advisor's Office of the OROO of the U. S. Atomic Energy Commission has made an exhaustive, statistical study of this problem at Oak Ridge. Inasmuch as the time interval covered is comparatively brief, this report is acknowledged to be a preliminary one, pending a follow-up study in the future. The conduct of the investigation was guided by the following considerations:

1. The basis of comparison was to be morbidity statistics inasmuch as the mobile nature of the Oak Ridge populace prevented the necessary follow-up to secure accurate mortality data. The data would be expressed in units of cases per 100,000 population.

2. The term "cancer" was defined to embrace all malignant neoplasms, including leukemias and lymphomas. This tended to maximize the incidence.

From the Office of Research and Medicine, Oak Ridge Operations Office, U. S. Atomic Energy Commission, Oak Ridge, Tennessee.

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Before any refined analysis could be attempted, certain data had to be obtained from source materials. It was found that:

1. Oak Ridge has had a minimal total population of 300,000 different persons in the period from October, 1943, to January, 1948. This was determined by an investigation into the number of badges issued, allowance being made for duplications and for children without badges.

2. The median length of residence was found to be nine and eight-tenths months, after a suitable weighing of housing records.

3. The age distribution of the population as of January, 1948, showed a preponderance of young children and young adults with a corresponding deficiency in older children and adults more than 40 years of age. A comparison of the Oak Ridge population distribution with the 1940 national census is shown in Fig. 1.

Data were not available to determine the age distribution during the peak construction and operating days in 1944 and 1945. Un-

TABLE 1

PER CENT AGE DISTRIBUTION OF OAK RIDGE EMPLOYEES AND RESIDENT HOUSEHOLDS

Age	*Male*	*Female*	*Total*
Under 5	14.0	13.6	13.8
5– 9	10.1	10.2	10.2
10–14	5.9	5.8	5.8
15–19	4.5	6.6	5.6
20–24	7.3	15.2	11.2
25–29	14.2	13.2	13.8
30–34	12.2	10.9	11.5
35–39	10.7	7.4	9.1
40–44	7.9	4.4	6.2
45–49	4.3	3.6	3.9
50–54	3.9	2.9	3.4
55–59	2.2	1.9	2.0
60–64	1.2	1.0	1.1
65–69	0.9	1.5	1.2
70–74	0.5	1.5	1.0
75–and over	0.3	0.4	0.3
	100.1	100.1	100.1

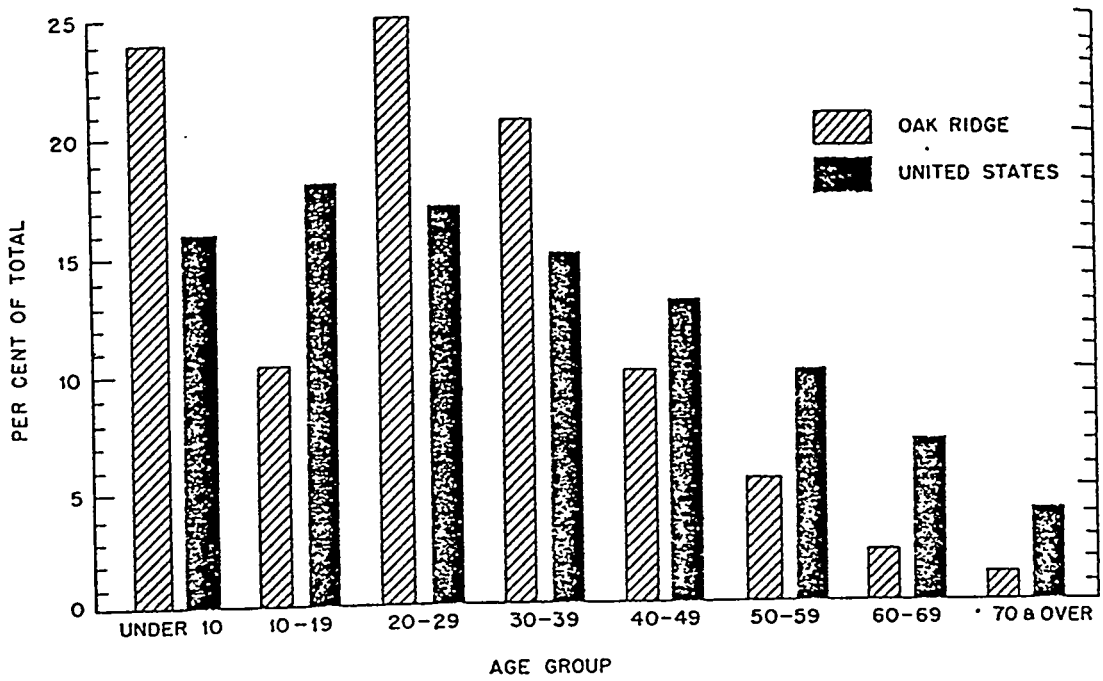

FIG. 1. *Comparison of age distribution between Oak Ridge and the United States.*

doubtedly, there has been a shift in ages, but the available evidence is negative in character. The mortality rate among residents has not varied significantly from year to year, as might be expected from an influx or efflux of older people. It is conjectured that in the past there were fewer children and more adults in the over-40 age groups. As was done previously, we wished to avoid underestimating the morbidity data. The distribution of Table 1 has been used as a conservative estimate.

Since there are so comparatively few cases of cancer among children, a slight overestimation has a very small effect. Underestimation in the older population groups, on the other hand, would tend to increase the over-all morbidity data, when standardized by age.

Preliminary Findings. In January, 1944, H. F. Dorn[3] published his findings of cancer morbidity rates based on intensive studies of eleven large American cities* and their surrounding counties. He found that the annual incidence rate was about 230 per 100,000 white population.

The discrepancy between the Oak Ridge rate of 123 per 100,000 was so great statistically that further data were sought from the twenty-four states which, by law or regulation, require the periodic reporting of new cancer cases. Responses and data were received from twenty states.†

In Table 2 may be found a tabulation of incidence rates in the reporting states averaged for all years reported since 1943. For comparison is the Oak Ridge rate, standardized by the population age distribution of each state as reported in the 1940 census. The median rate, as reported, is 100.7 per 100,000 population, significantly different from Dorn's rate of 230 *a fortiori*. In the light of Table 2, a state analysis and comparison appears useless.

* Atlanta, Pittsburgh, Detroit, Chicago, New Orleans, Dallas, and Fort Worth, San Francisco, Birmingham, Philadelphia, and Denver.

† Alabama, Arkansas, Colorado, Delaware, Georgia, Idaho, Kansas, Louisiana, Michigan, Minnesota, Mississippi, Montana, New Mexico, New York, North Dakota, Oklahoma, Pennsylvania, South Carolina, Texas, and Utah.

TABLE 2

COMPARISON OF ANNUAL STATE CANCER MORBIDITY RATES PER 100,000 AND OAK RIDGE STANDARDIZED RATES

	Rate	
State	*State*	*Oak Ridge*
Alabama	91.7	92.9
Arkansas	16.8	99.9
Colorado	267.1*	121.1
Delaware	†	
Georgia	‡	
Idaho	†	
Kansas	130.9*	128.5
Louisiana	75.3	98.4
Michigan	†	
Minnesota	†	
Mississippi	121.4	93.5
Montana	211.1*	119.4
New Mexico	118.8*	90.3
New York	254.7§	130.0
North Dakota	162.8	107.8
Oklahoma	†	
Pennsylvania	†	
South Carolina	65.4*	84.6
Tennessee	68.9*	102.7
Texas	†	
Utah	100.7*	99.6

* Provisional for 1947 only.
† Program too recent for any reports.
‡ Morbidity data not supplied, since too meager for report.
§ 1946 only for New York State exclusive of New York City.

Patterns of morbidity reporting have not been thoroughly investigated. It is obvious that a great deal of the state differentials is based on reporting habits of individual physicians and hospitals in the different localities. Perrott found that: "The completeness of reporting varies in relation to disease and from state to state. Thus we find that when the reports made to the U. S. Public Health Service are compared with results of surveys, the case rates show a deficiency of 70 per cent for scarlet fever, and 80 to 90 per cent for measles and whooping cough."

Another contributing factor is the care with which different agencies investigate all the facts. Ciocco reported: "The 36 states (including the District of Columbia) which make a routine check of death certificates reported an average of 38 per cent more cases of meningitis per death, 20 per cent more cases of poliomyelitis, 51 per cent more cases of scarlet fever, and 38 per cent more cases of pneumonia than do the 13 states which make no such check."

This does not deny that incidence rates do not vary from state to state, but the Dorn study discovered that the incidence of cancer was almost 50 per cent higher in the South than in the North, with the West playing an intermediate role. Reference to Table 2 shows that Colorado and New York, western and northern states respectively, have the highest reported morbidity, while the southern states have the lowest.

In the national study of Dorn,[3] 64 per cent of the cases of cancer were confirmed by microscopic examination in the laboratory. In Oak Ridge, such confirmation was to be had in 77 per cent of the cases. It was conjectured that after a correction for this difference, the discrepancy in ratio may no longer be significant.

In order to make the necessary correction, it was reasoned that according to the national data, for every 100 proved cases of cancer, there were fifty-six clinically diagnosed cases, while in Oak Ridge the ratio of proved to presumptive (clinically diagnosed) cases was 100:30. Hence, nationally, there were 26 per cent more cases suspected for each 100 microscopically proved cases.

Following this line of thought, an additional 26 per cent of the 151 proved cases of cancer in Oak Ridge was added to the grand total, making 222 cases in all, with 64 per cent proved by biopsy or autopsy. But this new total reduces to an adjusted rate of 147 per 100,000 annually, which difference still could very rarely arise through chance factors alone.

Detailed Findings. Although Oak Ridge comprises a cosmopolitan population representing all sections of the United States, the bulk of the populace is undoubtedly of Southern origin. Of the 196 people with cases of cancer discovered here, 140, or 71.4 per cent, were born in the South. Included in the 140 were sixty-one native Tennesseans who alone constituted 31.1 per cent of the total. Northerners accounted for forty-five, or 23.0 per cent; Westerners, three cases, or 1.5 per cent; and there were eight cases, or 4.1 per cent, with unknown nativity. Eliminating the unknown cases, the percentage distribution

of South, North, and West is 74.5 per cent, 23.9 per cent, and 1.6 per cent respectively. Using these latter figures as weights, an overall percentage distribution of cancer primary sites was computed from regional data given by Dorn.[3] Using these per cents, hypothetical expected values of cancer primary sites were computed separately for white males and females. The white female hypothetical and observed data are shown in Table 3.

TABLE 3

DISTRIBUTION OF CANCER PRIMARY SITES FOR WHITE FEMALES IN OAK RIDGE, EXPECTED AND OBSERVED

Site	*Expected*	*Observed*
Digestive organs	13.7	12
Genital organs*	48.6	59
Skin	16.9	13
All others	12.8	8
TOTAL	92.0	92

* Includes Breast.

The value of chi-square was 5.16, which, with 3 degrees of freedom, may occur between 10 and 20 per cent of the time owing to chance fluctuations.

Similar data for white males is given in Table 4.

TABLE 4

DISTRIBUTION OF CANCER PRIMARY SITES FOR WHITE MALES IN OAK RIDGE, EXPECTED AND OBSERVED

Site	*Expected*	*Observed*
Buccal cavity	13.2	9
Digestive organs	22.4	14
Respiratory organs	6.2	12
Genital organs	8.9	5
Urinary organs	5.8	5
Skin	32.7	38
All others	9.8	16
TOTAL	99.0	99

In the case of white males, chi-square was 16.52 which, for 6 degrees of freedom, would occur in less than 2 per cent of the cases by chance. This might easily represent a significant discrepancy, whereas the female primary sites do not differ significantly from their expected values.

An analysis of Table 4 indicates that the greatest contribution to the chi-square occurs among cancers of the respiratory system. A tentative hypothesis that the cause may lie in the dangers of working with radioactive chemicals has to be abandoned almost immediately. A breakdown of the males into the dichotomous classes of those whose work involved exposure to radioactivity and all others revealed the following interesting 2 × 2 contingency table:

Site	*Exposed Males*	*Other Males*	*Total*
Cancer of respiratory system	2	10	12
All other cancer	29	58	87
TOTAL	31	68	99

A much greater percentage of *nonexposed* males had cancer of the respiratory system. A breakdown of the ten occupations reveals nothing significant. They include a minister, a town bus driver, an elderly dependent, some construction laborers, etc. There is, however, no significant difference between the two classes.

A possible clue to the correct explanation may be found in another report by Dorn[2] in which he states that, between 1914 and 1931, the death rate from cancer of the lungs and pleura increased among white males in the United States about 4.5 times (450 per cent) while the increase in mortality for all forms of cancer combined was only 20 per cent. This represents an average increase of 10.5 per cent per year in cancer of the lungs and pleura. During the period from 1930 to 1931 to 1939 to 1940, the increase in mortality from cancer of the respiratory system rose 102 per cent, or about 11.3 per cent per year.

Confirmatory evidence of the continuance of this trend for the current decade comes from various other sources. The Kansas State Department of Health reported that whereas deaths from cancer increased only 10.0 per cent from 1940 to 1947, the mortality from cancer of the respiratory system increased 92.9 per cent. Similarly, among males in

Minnesota, the cancer death rate increased 13.4 per cent from 1940 to 1946, the mortality among males from cancer of the respiratory system increased 66.2 per cent. A comparison of the annual reports of the New York State Department of Health[8,9] for 1940 and 1944 indicated an increase of 53 per cent in the *incidence* of cancer among males. In Kansas, the mortality increased an average of 13.3 per cent per year; in Minnesota it increased an average of 11.0 per cent per year. In New York, the average increase in incidence of cancer of the respiratory system was 13.3 per cent during that period.

Clinical evidence of the rapid growth of cancer of the respiratory system is also abundant. Ochsner[10] reported: "The incidence of bronchiogenic carcinoma is definitely increasing as shown by the fact that the incidence at autopsy has increased within the past two decades. In the Charity Hospital in New Orleans in 1931 the incidence of bronchiogenic carcinoma as determined at autopsy was 0.47 per cent, whereas in 1940 the incidence had risen to 3.2 per cent. During the same period of time the incidence of primary gastric carcinoma as determined at autopsy varied very little and remained about 2.5 per cent."

It is widely believed that the increased incidence of cancer of the respiratory system "is due chiefly to the greater frequency of smoking."[11] Roffo, quoted by Ochsner, "stated the conviction, on the basis of his clinical observation of 78,000 patients treated in the University Institute for Experimental Medicine and for the Study of the Treatment of Cancer in Buenos Aires, that tobacco is the most important factor in determining the localization of cancer. He was able to produce carcinoma experimentally by applying tar derived from various tobaccos." Even further, Ochsner[11] reported finding a definite statistical parallelism between the incidence of bronchogenic carcinoma and the sale of cigarettes.

In the light of this evidence, a reasonable explanation may be tendered for the large value of chi-square. If the above-mentioned trend were also characteristic of Oak Ridge, and were extrapolated to the present, about twice the number of the cancers of the respiratory system expected on the basis of the 1938 percentages in the Dorn report should have appeared in the town. This is precisely what did occur. Obviously, an increase in one percentage means a decrease in another if the total is to remain 100 per cent. Consequently, an underestimation of cancer of the respiratory system means overestimation elsewhere. Following this vein of thought, a new set of expected values was set up by doubling that of the respiratory system and reducing all others proportionately. This appears in Table 5.

TABLE 5

CORRECTED DISTRIBUTION OF CANCER BY PRIMARY SITES FOR WHITE MALES IN OAK RIDGE, OBSERVED AND EXPECTED

Site	*Expected*	*Observed*
Buccal cavity	12.3	9
Digestive organs	20.9	14
Respiratory system	12.5	12
Genital organs	8.3	5
Urinary organs	5.4	5
Skin	30.6	38
Others	9.0	16
TOTAL	99.0	99

Computations now reveal a value of chi-square equal to 11.90, which may occur, by pure chance, between 5 and 10 per cent of the time. Hence, under these new assumptions, the distribution of cancer by primary sites in Oak Ridge does not significantly differ from a weighted national average.

The corrections in the respiratory systems percentage would have only a negligible effect upon the female distribution inasmuch as the incidence of malignant respiratory diseases among females is so much lower than among males and the percentage increase was also considerably lower.

One of the major purposes of the present investigation was to note any significant differences between the incidence of cancer among employees whose jobs carried them into exposed areas and all others. Of the 196 cancer cases, thirty-six, or 18.4 per cent, might have had occasion, in their work, to

be in the restricted areas in Oak Ridge. Of the 300,000 employees and residents, it is estimated that no less than 60,000, or 20 per cent, could have had access to the areas of possible danger. There is no reason at all, on the basis of this study, to accept the hypothesis of greater susceptibility to cancer among exposed workers.

General Considerations

Mortality rates, which are more generally available than morbidity rates, are low in general in Oak Ridge. In 1947, the death rate from all forms of heart disease was 46.2 per 100,000. The national rate hovers about 320 per 100,000. Even after making due allowance for the fact that the Oak Ridge figure is a crude number (the Public Health Department has not standardized its data for age since no age distribution had previously been known), the difference is obviously highly significant. This pattern holds true for other diseases.

The ratio of cases to deaths from cancer varies somewhere between 3:1 to 5:1. Dur-

TABLE 6

NUMBER OF CASES OF CANCER IN OAK RIDGE, TENNESSEE BY AGE, SEX, AND PRIMARY SITE GROUPS

Primary site	Sex	Age in years														
		0–9	10–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75 & over	Total
Buccal cavity	Male	0	0	1	1	0	3	1	1	0	2	0	0	0	0	9
	Female	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Digestive organs	Male	0	0	0	0	0	3	3	1	1	2	2	2	0	0	14
	Female	0	0	1	0	2	2	1	1	0	1	2	1	1	0	12
Respiratory organs	Male	0	0	0	0	2	0	1	3	2	3	0	0	1	1	12
	Female	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Genital organs incl. breast	Male	0	0	0	0	1	1	0	0	3	1	0	1	1	0	8
	Female	0	0	3	4	13	10	13	2	5	5	1	1	0	2	59
Urinary organs	Male	1	0	0	1	1	1	1	0	0	0	0	0	0	1	6
	Female	0	0	1	0	0	1	0	1	0	0	0	0	0	0	3
Skin	Male	0	2	0	1	2	5	4	5	7	3	3	2	2	1	37
	Female	0	0	0	1	2	2	1	2	2	2	1	0	0	0	13
Brain	Male	1	0	0	1	1	0	1	0	0	0	0	0	0	0	4
	Female	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1
All others & unknown	Male	0	0	0	0	2	4	4	1	0	0	0	0	0	1	12
	Female	0	0	0	1	0	0	3	0	1	1	0	0	0	0	6
TOTAL	Male	2	2	1	4	9	17	15	11	13	11	5	5	3	4	102
	Female	0	0	5	6	17	15	18	7	8	9	4	2	1	2	91

TABLE 7

ANNUAL INCIDENCE RATES PER 100,000 OF CANCER IN OAK RIDGE, TENNESSEE BY AGE, SEX, AND PRIMARY SITE

Primary site	Sex	Age in years															
		0–9	10–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75 & over	Crude Total	Standardized total*
Buccal cavity	Male	—	—	11.1	5.8	—	22.8	10.3	19.0	—	74.0	—	—	—	—	7.3	8.6
	Female	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Digestive organs	Male	—	—	—	—	—	22.8	30.9	19.0	20.8	74.0	135.7	180.9	—	—	11.4	20.3
	Female	—	—	5.4	—	15.1	22.2	18.6	22.8	—	43.2	164.1	54.7	54.7	—	9.8	17.2
Respiratory organs	Male	—	—	—	—	13.3	—	10.3	56.8	41.8	110.9	—	—	—	270.9	9.8	18.8
	Female	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Genital organs incl. breast	Male	—	—	—	—	6.6	7.6	—	—	62.6	37.0	—	90.5	162.9	—	6.5	12.4
	Female	—	—	16.2	24.9	97.8	110.8	242.3	45.6	141.4	215.9	82.0	54.7	—	410.2	48.4	71.9
Urinary organs	Male	3.4	—	—	5.8	6.6	7.6	10.3	—	—	—	—	—	—	270.9	4.9	8.5
	Female	—	—	5.4	—	—	11.1	—	22.8	—	—	—	—	—	—	2.4	2.7
Skin	Male	—	15.7	—	5.8	13.3	38.1	41.3	94.6	146.1	110.9	203.5	180.9	325.7	270.9	30.1	54.7
	Female	—	—	—	6.2	15.1	22.2	18.6	45.6	56.8	86.3	82.0	—	—	—	10.7	17.9
Brain	Male	3.4	—	—	5.8	6.6	—	10.3	—	—	—	—	—	—	—	3.3	2.3
	Female	—	—	—	—	—	—	—	22.8	—	—	—	—	—	—	0.9	1.4
Others & unknown	Male	—	—	—	—	13.3	30.5	41.3	19.0	—	—	—	—	—	270.9	9.8	12.8
	Female	—	—	—	6.2	—	—	56.0	—	28.4	43.2	—	—	—	—	4.9	8.0
TOTAL	Male	6.7	15.7	11.1	22.9	60.0	129.3	154.5	208.2	271.3	406.9	339.2	452.2	488.4	1083.7	82.9	138.4
	Female	—	—	26.9	37.2	128.0	166.3	335.6	159.6	226.3	388.5	328.1	109.3	54.7	410.2	77.0	119.0

*Standardized by estimated U. S. population, July 1, 1946.

ing the period studied, there have been forty-six recorded deaths from cancer. A total of 196 cases has been discovered, which is a ratio of 4.3:1 in Oak Ridge. It is believed that the death rate is somewhat higher than reported because after one leaves his position, he must vacate his living quarters in town. Therefore, anyone too ill to work cannot live, and die, in Oak Ridge unless he is being supported by, and living with, some other employee. This might have a downward bias on the heart-disease mortality quoted above, but cannot alter the over-all picture.

TABLE 8

INCIDENCE OF CANCER PER 100,000 IN OAK RIDGE, TENNESSEE BY AGE

Age	*Incidence*
0– 9	3.4
10–19	7.2
20–24	21.8
25–29	29.9
30–34	92.0
35–39	144.4
40–44	219.1
45–49	186.1
50–54	252.2
55–59	398.4
60–64	334.2
65–69	238.5
70–74	163.7
75–and over	700.4
CRUDE TOTAL	80.0
STANDARDIZED TOTAL*	123.1

* Standardized by estimated U. S. population, July 1, 1946.

Lombard and Warren[6] reported that, "There is greater susceptibility to cancer in persons having one cancer than in the normal population" on the basis of studies made at Massachusetts state-aided cancer clinics.

In 1946, in a report by Lombard, Levin, and Warren[7] it is stated: "Persons with skin cancer are predisposed to other skin cancers. There is also an indication that males with lip cancers have some predisposition to multiple skin cancers."

On the basis of these studies, it would appear likely that cancer incidence, particularly skin-cancer incidence, would be highest in that segment of the population that had previously been known to have had a skin cancer. But this would tend to be an older age group and Oak Ridge is very predominantly a younger age group. It would therefore be reasonable to suppose that a partial (a small part, no doubt) explanation of the low cancer incidence in Oak Ridge lies in the fact that the younger people are less predisposed toward new cases of cancer, since they are less likely to have previously developed a case. Standardization for age would remove only a portion of this difference.

There has been a limited amount of statistical research conducted to determine the effects of one's socio-economic group on cancer susceptibility. In England, Stevenson, as reported by Levin,[4] found a definite progressive increase in cancer of certain sites in each "lower" socio-economic group. His classifications were professional, skilled workers, and unskilled workers with two intermediate groups. This progression generally held true also for women when classified by their husbands' occupations.

Confirming studies were made in the United States by Knight and Dublin and Whitney.[4] Lombard and Doering[4] discovered that, in Massachusetts, the foreign born and those of foreign parentage had higher rates for cancer of the buccal cavity and stomach cancer. Analyzing 1865 mortality returns in Providence, Rhode Island, Chapin[4] found

TABLE 9

DISTRIBUTION OF CANCERS IN OAK RIDGE, TENNESSEE BY HISTOLOGICAL DIAGNOSIS

Diagnosis	*Number*		*Per cent*	
Carcinoma	157		80.1	
Squamous-cell		44		22.5
Basal-cell		24		12.3
Adenocarcinoma		25		12.8
Duct-cell		4		2.0
Carcinoma simplex		3		1.5
Other specified type		14		7.1
Unspecified carcinoma		43		21.9
Sarcoma	12		6.1	
Leukemias	6		3.1	
Lymphatic		4		2.1
Other specified type		2		1.0
Melanoma	6		3.1	
Seminoma	2		1.0	
Malignant papilloma	2		1.0	
All others	11		5.6	
TOTAL	196		100.0	

cancer mortality to be twice as high in the lower as contrasted with the higher economic groups.

There is no immediate, apparent explanation to account for these discrepancies. Better diagnostic services, available to the upper-income classes, would tend to support a greater, rather than a lesser, incidence of cancer. The type of cancer studied in these reports includes both the easily recognizable forms of the skin and those more apt to be missed in a casual examination, such as cancer of the stomach.

The educational and economic level of the Oak Ridge community is one of the highest in the country. There has probably existed here a larger proportional concentration of professional and skilled people than in almost any other American community. Concurrently, partially as a result of stringent security regulations, the proportion of native-born citizens in Oak Ridge is very high. In fact, not one case of cancer occurred, as far as could be determined, in someone born outside the continental limits of the United States. If the various studies referred to above are substantially correct, these atypical characteristics of Oak Ridge may explain a large part of the discrepancies noted.

Levin[5] has reviewed the evidence in support of socio-economic factors in explanation of differences in the incidence of cancer. He stresses the desirability of epidemiological studies to determine the significance of these factors. The situation in Oak Ridge tends to confirm this hypothesis, but the over-all relative uniformity of socio-economic status prevents the establishment of a control group to carry out precise statistical tests of significance. Such tests would provide valuable contributions to the literature.

Conclusions

The age-standardized incidence rate of cancer among Oak Ridge employees and their resident dependents is 123 cases annually per 100,000. This is significantly lower than the accepted national rate of 230 per 100,000 annually.

The conflicting and generally inadequate state data make it unfeasible to make a state-by-state comparison with Oak Ridge.

The proportion of employees who have possibly been exposed to occupational radiation levels and who have developed cancer is about equal to their proportion in the entire population, indicating that there is no reason to believe that they are more susceptible to cancer.

The low cancer rate is in harmony with the low death rate, in Oak Ridge, from most diseases and within the accepted tolerance limits of the ratio of cases of cancer to cancer-caused deaths.

The relative proportion by primary sites of occurrence among white females with cancer is not significantly different from the nationally based expected values.

Among white males a significantly higher proportion of cancer of the respiratory system was found than might be expected by chance from the 1938 national averages. A tentative explanation on the basis of a long established upward trend in cancer of the respiratory system among males was offered.

Reference was made to other authorities who offer evidence of the relationship between one's socio-economic group and his susceptibility to cancer.

Tables 6, 7, 8, and 9 provide a detailed tabulation of the data on which this paper is based.

(For references see page 575.)

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